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TECHNOLOGY UTILIZATION

MATERIAL CUTTING, SHAPING, AND FORMING

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A COMPILATION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA SP-5922(01)

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TECHNOLOGY UTILIZATION OFFICE 1970
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.

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Foreword

The National Aeronautics and Space Administration has established a Technology Utilization Program for the rapid dissemination of information on technological developments which have potential utility outside the aerospace community. By encouraging multiple application of the results of its research and development, NASA earns for the public an increased return on the investment in aerospace research and development programs.

This publication is part of a series intended to provide such technical information. A selection has been made from the wide technological spectrum covering the cutting, shaping and forming of materials in their application to industrial methods. The present compilation includes a variety of items reflecting in most cases improvements in terms of time saving and cost reduction, combined with greater uniformity of result. Even sophisticated and extremely hard metals such as rhenium are now amenable to forming and machining without risk of damage. New and little-known materials, (for example zirconia, a ceramic prestressed with tungsten cables and combined with silicon carbide) are being used in the commercial manufacture of numerous products.

Additional technical information on individual devices and techniques can be requested by circling the appropriate number on the Reader's Service Card included in this compilation.

Unless otherwise stated, NASA contemplates no patent action on the technology described.

We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this compilation.

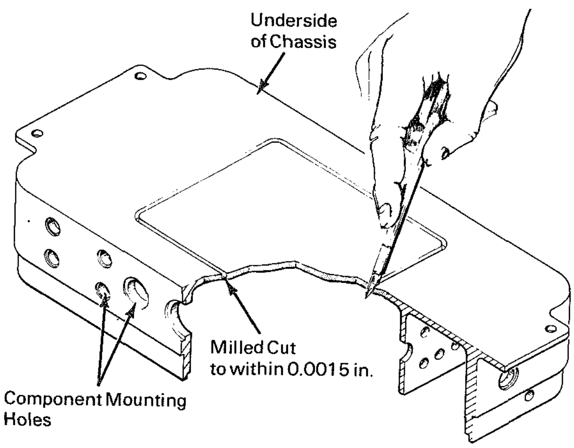
Ronald J. Philips, *Director*
Technology Utilization Office
National Aeronautics and Space Administration

Contents

Section 1. Cutting

MACHINING ELECTRONICS CHASSIS WITH COMPONENTS INSTALLED

The disclosed technique makes it possible to do machining work on an electronics chassis after installation of parts. It no longer is necessary to remove components from the chassis before attempting any milling. Considerable time and expense, together with multiple problems, are thus eliminated by a relatively simple means (see figure.)



Among the chief dangers was that of metal chips falling into the circuitry of the electronic components and causing shorts. Necessarily, the removal of components prior to machine work entailed their subsequent replacement.

The new process consists of milling a profile on the bottom of the component chassis to within .0015-inch of breakthrough, then using a sharp instrument to complete the cut.

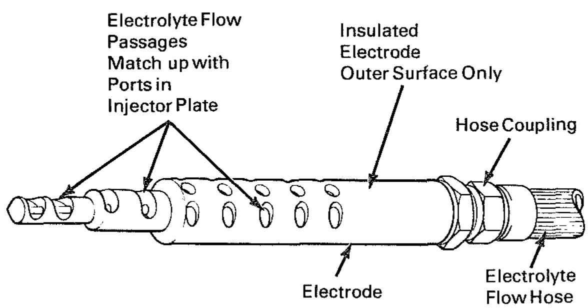
Source: M. A. Scott of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-90821)

No further documentation is available.

ELECTROMECHANICAL DEBURRING PROCESS

The use of insulated outer-surface controlled flow electrodes to perform the electromechanical machining of burrs eliminates many problems formerly encountered. Chief among these was the danger of metal filings being left inside a fabricated container after falling off.

The accepted method of deburring the inside of holes drilled in a container was at best tedious and time consuming. The new process should therefore be applicable in the manufacture of typical hydraulic valve bodies or fuel injectors where numerous intersecting holes are drilled or bored. Electrodes are first fabricated to fit the hole configurations and the electrode is then fitted into the hole. Electrolyte is next pumped into the electrode so that it exits through the hole. When the electric current is turned on, since only the outside surface of the hole is insulated (with linear polyethylene), the area just inside acts as an electromechanical machine tool. Since the burrs are the closest



points to the insulated portion of the electrodes, any such burrs can be removed without appreciably changing the dimension of the hole.

An electropolishing solution (EG-55) is used as the electrolyte, since it produces a polished finish and can sustain a high current density, thus reducing the time required to machine. Where an injector plate is specifically concerned, certain procedures must be observed with care. First, the entire length of each porthole is hand- or machine-reamed to remove all large burrs which would otherwise block the electrode. Secondly, all metal chips and burrs which were left in the holes after drilling must be removed by blowing, washing out, or other means. The electrode is then inserted and aligned in the hole and the timer dial set to five minutes for the smallest electrode or eight minutes for any other. The lower voltage limit is set at approximately 10 volts; the upper limit at 24 volts. When the cycle starting button is pushed, the pump comes on first. Then, after the solution is flowing, the current and timer automatically turn on. The current control knob is adjusted so that the ammeter reads 120 amps for the small electrode and 150 amps for the others. When the time cycle is completed, the system automatically shuts off. After a fuel injector of any type is described (see figure), it should be steam cleaned to remove the green metal hydroxides and salts which result from the electrochemical process.

If a short circuit occurs between the electrode and the drilled hole, voltage at once drops toward zero as the current increases. When the voltage reaches the lower limit set on the voltmeter, the entire system shuts down. The risk of accidental damage is thus eliminated.

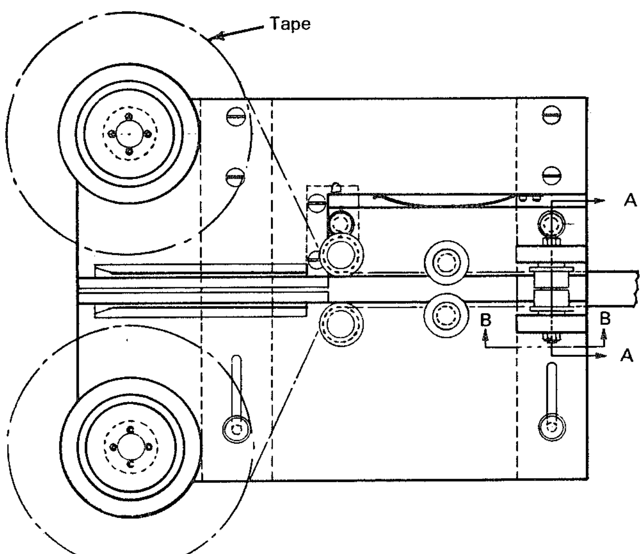
Pump failure (resulting in the solution not reaching the electrode) causes a voltage increase to the open circuit value or 25V. The upper limit voltage sensor is then tripped and the system shuts off. The electrolyte used in this process consists of strong acids (mostly sulfuric and phosphoric) and should therefore be treated with extreme caution.

Source: Robert I. Gellert of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-90810)

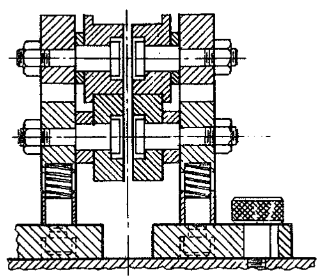
Circle 1 on Reader's Service Card.

FILM CUTTING AND SEALING TOOL

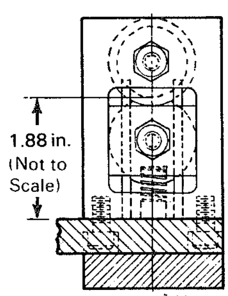
A progressively designed tool lends itself to extensive use by industrial X-ray service laboratories handling short lengths of daylight packing film strip. Many facilities have occasion to use daylight pack in other than standard widths. These requirements pose handling problems which involve time and additional expenditure.



Arrangement for Sealing Sides of Strips



View A-A



View B-B

The subject innovation, which has now been perfected with a view to cutting and sealing film strip, features a tool made up of two components: a film cutter and sealer, mounted on a common base. This represents a new technique as applied to film preparation in the darkroom. It is mechanical, faster, easier, more uniform, and neater than the manual process.

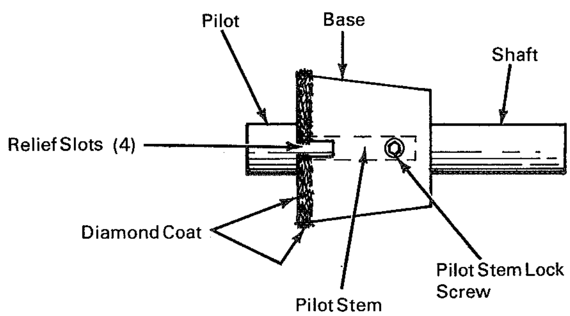
The cutter is a standard small paper cutter. Mechanical stops allow 7- x 17-inch lead oxide "ready pack" film to be cut in 7-inch long strips in widths varying from 1 to 3 inches. The sealer shown in the figure consists of a main element to be used with either an edge or end sealing accessory. The latter is essentially a plate on which are mounted a holder for a roll of tape and various guide rollers. The 7-inch long strips are pulled through these rollers which simultaneously seal the edges with lightproof tape. Once the latter is in place, cut lengths of daylight pack strip film are also pulled through a series of rollers which seal one end with light proof tape. To seal the opposite end, the strip is reversed and the process repeated.

Source: D. K. Mitchell of
The Boeing Company
under contract to
Marshall Space Flight Center
(MFS-14057)

Circle 2 on Reader's Service Card.

DIAMOND COATED SPOTFACER

A diamond coated spotfacer for cutting plastic and fiberglass laminate material offers numerous advantages which include savings in man-hours



and overall job time, reduced tool costs, improved quality of the finished assembly, and elimination of possible heating and burning of the material. In addition, delamination of the hole area no longer occurs. The novelty of the process is in the design of the cutter which includes a pilot (see fig.) and four relief slots in the diamond coat.

The special base tool, with its diamond coated face, can maintain ±0.005 in. tolerance on hole diameter. It is ideal for either a few or a large number of assemblies and hole sizes and eliminates the cost of replacement and resharpening.

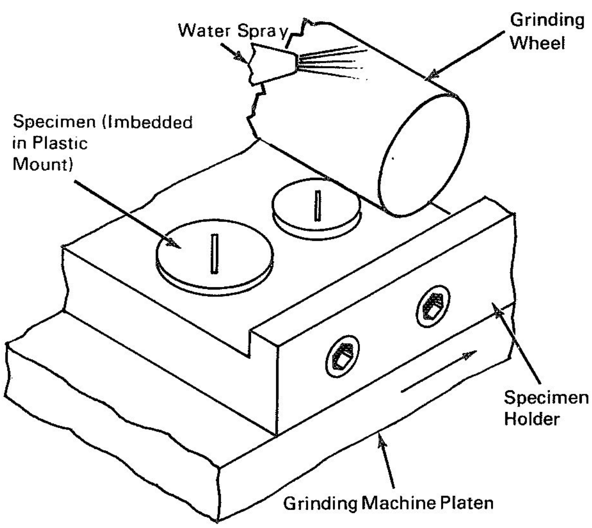
Source: Gilbert S. Hanes of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-11484)

No further documentation is available.

AUTOMATIC ROUGH GRINDING OF METALLOGRAPHIC THIN GAGE EDGE SPECIMENS

A recent process makes it possible to perform automatic grinding of the edges of thin sheet metallurgical specimens using a wet profile grinding machine with a special specimen holder. As much as 1/8 inch can be taken off the combined surfaces of up to 12 specimens at a time. If 0.0001 inch or less is removed with each pass under the wet profile grinding wheel, the metallurgical structure of the specimen remains unaffected.

Ordinarily, the rough wet grinding of the edges of thin sheet materials is done by hand, each specimen being ground separately. The object is to remove from the edges the material which has been



affected by the shearing or sectioning processes during specimen preparation. The hand method is a time consuming process and specimen uniformity is often poor.

The specimen holder (see fig.) made from No. 416 stainless steel, features holes for 6 1-1/2-in. diameter specimens and 6 1-in. diameter specimens. These are alternated in two equal rows. A 1/32-in.-clearance in hole diameter is allowed for easy insertion of the specimen. Individual holes for 28 setscrews (1/4-in.) are drilled and tapped from the holder edge. The specimen holder is inverted onto a flat surface and specimens are inverted in the holder with the surfaces to be ground facing downward. They are then locked in place with individual setscrews. All specimens are at the same height, relative to the grinding wheel. The holder is again inverted and magnetically clamped to the platen of the grinding machine. When the automatic grinding is completed, specimens are finish ground, polished, etched, microscopically examined, and photographed in the usual manner.

Source: Bland A. Stein
Langley Research Center
(LAR-90151)

No further documentation is available.

LINEAR SHAPED CHARGE WITH TWO-DIMENSIONAL CUTTING ACTION

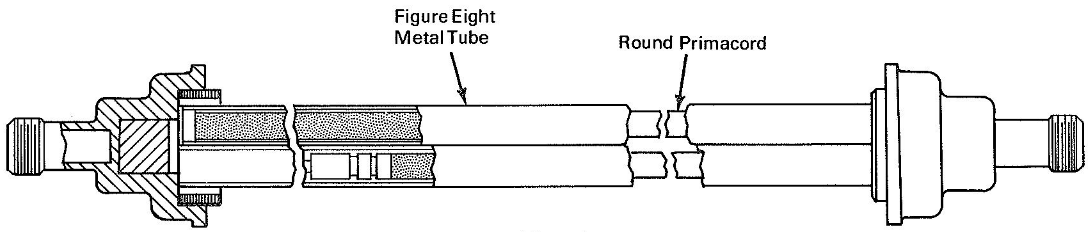


Figure 1

Metal cutting action in two directions is the subject of a design that uses a linear shaped explosive charge. The device consists of a figure-eight metal tube, shown in Figure 1, with a length of primacord explosive in each half of the tube. The charges are activated by a cap at either end.

The configuration of the metal tube provides the two-directional shape cutting effect. The cutting action is directed by the joined portion of the figure-eight tube indicated in Figure 2. In order to cut two metal surfaces, the tube containing the primacord is placed between them. This technique is swift and high quality cutting can be maintained.

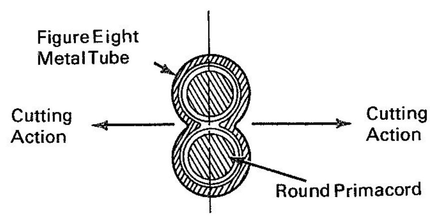


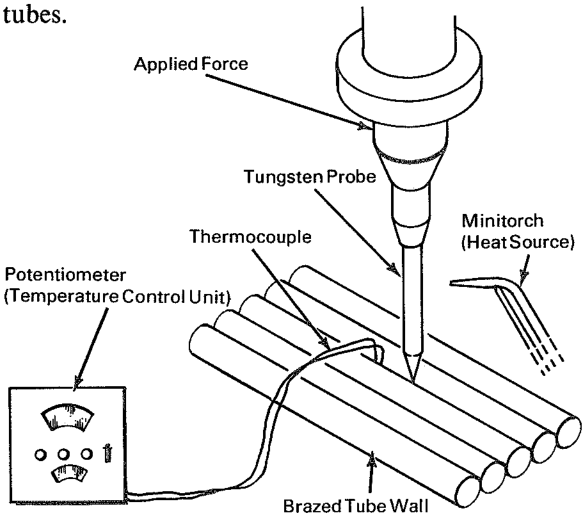
Figure 2

Source: M. L. Davis of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-91732)

Circle 3 on Reader's Service Card.

SEPARATION OF BRAZED TUBES FOR INSTRUMENT INSTALLATION

A method has been developed where a heated probe operates under controlled temperature and pressure for the purpose of separating brazed tubes.



Industrially, the principle of controlled pressure and monitored temperature is applicable to any situation where it becomes necessary to melt brazing without damage to brazed surfaces.

During past attempts of this kind, sometimes for the purpose of instrument installation, the use of uncontrolled heat and force tended to fracture or anneal the tubes.

The new probe, which is made of tungsten, is applied with a steady predetermined force, and generates a temperature just below the annealing point of the tube material. The tungsten tip is of a flattened screwdriver type and the probe is heated with a minitorch, using a thermocouple attached approximately one inch from the tip. Heat is monitored through a potentiometer (see fig.) and as the probe begins to soften the braze, it also starts moving. It is this motion which separates the tubes from the braze alloy until a complete passage is produced.

Source: G. S. Gill, W. R. Koenig and A. J. Garrett of North American Rockwell Corp. under contract to Marshall Space Flight Center (MFS-90944)

Circle 4 on Reader's Service Card.

MINIMIZING HOLE DEBURRING

An innovation now makes it possible to reduce to a minimum the need for hand deburring drilled or bored holes after machining a workpiece.

This technique constitutes a big improvement over former practice when a workpiece with a critical hole was machined. Burrs invariably formed around the entry and exit to the hole and hand deburring was required. The process was a costly one since it often resulted in the rejection of a piece if too much material was accidentally removed.

Under the new process, the holes are protected by filling them with nonferrous alloy prior to machining. The alloy used for this purpose consists of the following metals: bismuth 50%; lead 26.7%; tin 13.3%; and cadimium 10%.The resultant alloy is hard, nonshrinking and fusible and has a very low melting point (158°F).

After machining is completed, the non-ferrous filling material is easily removed from the hole by immersing the workpiece in boiling water. With the alloy washed out, the hole can be cleaned with an appropriate stripper solution. This acts on the alloy without affecting the metal workpiece. Any burrs that may still remain will be small enough for easy removal with minor hand deburring.

Source: T. C. Myers of North American Rockwell Corp. under contract to Marshall Space Flight Center (MFS-90785)

No further documentation is available.

Section 2. Shaping

THIN WALL TUBE BENDING, USING CRYOGENICS

This inexpensive method of bending tubing filled with water and chilled down to cryogenic temperature (LN^2) produces results comparable to those obtained by earlier techniques. In addition, it eliminates the cost of melting and filling, as well as cleaning out ferro-bend. The improved method is particularly useful in the absence of special mandrels.

Thin wall bending formed in the past by the use of ferro-bend involved liquifying and cleaning problems. In many instances, special tools and mandrels also were required. This took considerable time and raised the cost correspondingly.

Following immersion in nitrogen (in accordance with the new method), the chilled tubing is removed and formed, using regular tube bending mandrels or tools. One end of the tube is left open during the freezing operation to allow for the expansion of water.

Source: Billy Freeman of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15850)

No further documentation is available.

ADAPTER FOR TUBE BENDING WITH MINIMUM FITTING-TO-RADIUS DIMENSION

A special adapter hook has been devised which will allow a commercial bender to bend a tube close to a flared end fitting. This is often necessary in a variety of plumbing installations where space is a prime consideration. The commercially available tube bender cannot alone produce this type of close proximity bend. Resultant improvisations usually are not satisfactory and at best consume more time than is necessary, with an attendant rise in cost.

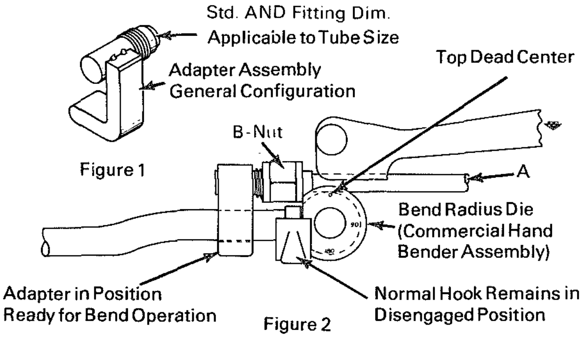


Figure 1

Figure 2

The new device consists (in addition to a commercially available tube bender) of a special adapter, easily fabricated in any shop. The adapter is a combination of bent tang and standard AND fitting welded together, as shown in Figure 1.

The procedure requires the tubing to be flared first, but since main usage of the adapter is applicable to ¼-inch tubing, this presents no problem. A B-nut and sleeve are then assembled on the tube and the B-nut is lightly torqued into the bend adapter as shown in Figure 2. The adapter tang placed under the tube bender handle replaces the normal hook which remains disengaged. With the tube (A) cradled in the bend radius die, pressure can now be applied to the tube (see downward arrow, Figure 2), with the curve beginning at top dead center, immediately behind the sleeve.

While the adapter has successfully been used in many plumbing problems requiring close tolerances with ¼-inch tubing, this innovation should also be readily applicable to ⅜- and ½-inch tubing.

Source: M. F. Hoff, Jr. of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15900)

No further documentation is available.

CONCEPTUAL METHOD OF PRODUCING SHELL SEGMENTS IN AGE FORMING

A recent effective tooling concept provides a method of adjusting for differences in curvature retention induced by grain direction, when metal parts with a symmetrical compound configuration are age-formed.

The advantage of this concept is that tooling can be produced with a conventional lathe or milling machine. The only apparent limitation is that it is confined to producing tooling for parts having a cup form with constant radii.

The accepted method of fabricating a compound contoured form to achieve a spherical segment is fairly complex. First it involves translation of the required surface to three-axis Cartesian coordinate points, or to polar coordinates. From these points the required form can be constructed either by a three-axis numerical controlled milling machine, or by making templates for the surface trace of lines through the coordinate points on planes at various stations parallel to the axis of the coordinate system. From these templates, hand-made molds can be fabricated for casting the required form. Such methods require either costly computer time or manual calculation.

Numerical control machining requires programming tape preparation and three-axis numerical control. The hand forming process involves excess expenditure of man-hours without guarantee of accuracy.

The technique here described will produce the required punch and die set necessary to age-form a spherical segment configuration.

Using results from tests, a graph of the ratios of the tooling spherical radii to both longitudinal and transverse grain direction part-developed radii has been prepared. Application of this tooling concept is developed in the following four steps: (1) a die radius is selected from the graph which will produce a radius in the longitudinal grain direction equal to the required part-spherical radius; (2) using the radius-ratio graph and longitudinal grain direction radius found in (1), a developed radius in the transverse grain direction is projected; (3) a punch and die set is machined with a spherical radius equal to the transverse grain direction determined in (2); (4) a part is then age-formed in a fixture using this punch and die set; (5) the resulting pattern is used as a "master" pattern to cast a punch from the concave side and a die from the convex side. The punch and die set is then indexed as to grain direction of the master pattern.

Source: Robert W. Lightstone of
The Boeing Co.
under contract to
Marshall Space Flight Center
(MFS-90453)

No further documentation is available.

SHARPENING TUNGSTEN KNIFE EDGE

A recent technique has eliminated the risk incurred while grinding a refractory metal such as tungsten for the purpose of securing a sharp cutting edge. Owing to the brittle character of tungsten, its sharpening to an edge with a radius of less than 25–50 μ has frequently resulted in chipping, with attendant waste of time and extra cost.

The required smooth final edge can now be obtained by electrolytic polishing with a strongly alkaline electrolyte. Twenty to 30% by weight NaOH or CsOH have been successfully used. The polishing cathode consists of a wand fabricated from 4-inch long, 3/16-inch-diameter stainless steel tubing, flattened to about 1/4-inch wide on one end. The hub from a hypodermic needle is silver soldered at the other end. A small piece of special cloth is folded over the flat tip area and held in place with a stainless steel clip. Cloth from an anode bag is usually adequate. It is essential, however, that none of the stainless steel be exposed in the electrode area. If direct metallic contact is made, it may burn the delicate tungsten edge. A small syringe filled with electrolyte is next inserted into the hub and the electrolyte forced gradually into the cloth through the opening in the flattened tube until the cloth is saturated. The required degree of saturation is determined by trial.

The part to be polished or sharpened is the anode and is connected to the positive terminal of a dc power supply. The polishing wand or cathode is connected to the negative terminal. Starting at approximately 10 volts, the precise voltage used must be adjusted to polishing conditions. With a 1/4-inch wide electrode, rubbed back and forth near the tip of the tungsten knife edge, a current of 0.5 to 1.5 amps has been found to polish a section half an inch long in two or three minutes. Every few minutes a small amount of electrolyte is forced through the cloth to remove dissolved tungsten. Excess electrolyte is blotted away with filter or absorbent paper. Polishing continues on both sides until microscopic examination shows that a suitable edge has been achieved.

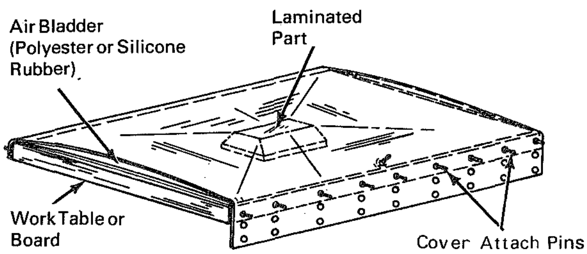
Source: William E. McKee of
Hughes Research Labs.
under contract to
NASA Pasadena Office
(NPO-90332)

No further documentation is available.

Section 3. Forming

CURING LAMINATES BY POSITIVE PRESSURE

A new and improved technique for bonding small laminated parts should prove of considerable value to industries concerned with laminated fabrication for a wide variety of commercial uses. Its potential for military work of this kind also is significant.



Usually, small laminated parts require clamps, ties, or tape in order to cure them properly and obtain adequate bonding of even quality. This is a slow and complicated process.

A quicker, more efficient (and therefore less expensive) way of obtaining the same result is by means of an inflatable bladder. The laminates to be cured are set up on a work table or flat surface; an air bladder is attached to the cure blanket, as shown in figure, and the bladder is then inflated. The result is a constant and even pressure on the sandwiched laminates, over their entire surface. If required, heat can be applied for curing (the air bladder will withstand cure cycle temperatures up to 500°F), or the work can be allowed to cure under "air dry" conditions.

Source: Homer W. Bailey and
Bertram R. Ulrich of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-16746)

No further documentation is available.

FABRICATION OF STRUCTURAL HONEYCOMB PANELS

A new process has been evolved which makes use of epoxy potting compound for edge-filling a prefabricated honeycomb panel cut to a required size. Individual panels with integral frames require no tooling and the process is applicable to all industrial honeycomb structure configurations, including compound curves.

Conventional fabrication techniques of structural honeycomb panels have always been costly and complex and therefore time-consuming. Fitting,

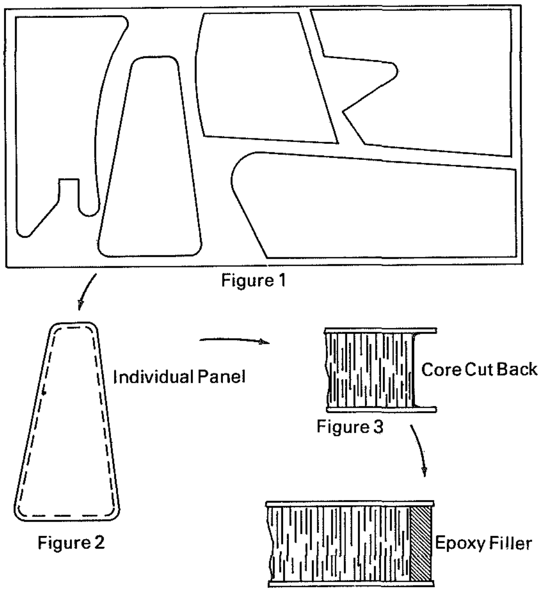


Figure 1
Figure 2
Figure 3
Figure 4

inspection, and tooling add to the problems, along with the need to fabricate and bond the panels individually.

The sequence of the disclosed process is as follows: (1) a rectangular panel, sized to include one or more configurations, is autoclave-bonded to produce a prefabricated honeycomb sandwich; (2) individual profiles are laid out on the prefabricated panel, shown in Figure 1; (3) panels are cut from this prefabricated panel using a bandsaw, sabresaw or similar cutting tool; (4) the honeycomb core is then cut or crushed back from the panel profile, shown in Figures 2 and 3; (5) the panel recess is filled with room temperature cure epoxy and allowed to harden; (6) the epoxy filled panel is then sanded or ground smooth to produce a structural panel with integral frame; (7) fittings or hardware are attached by means of potted inserts.

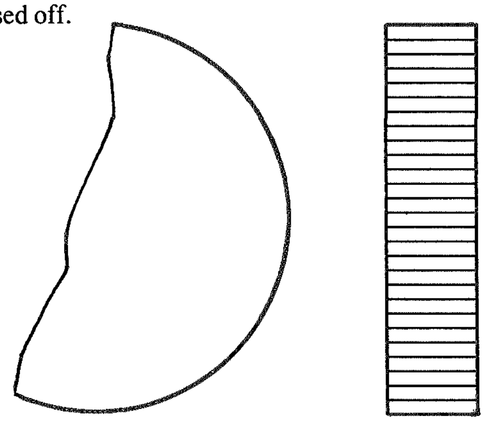
Source: Avery E. Corywell of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-90559)

No further documentation is available.

HEAT AND VACUUM FORMING OF HIGH DENSITY PHENOLIC CORE

A new method has been perfected which represents a 100 percent improvement over past attempts to contour high density phenolic honeycomb core around sharp angles.

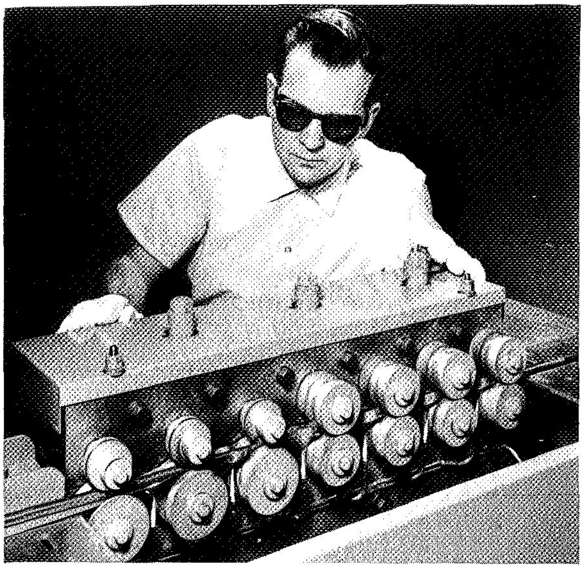
The desired shape of phenolic core can be attained by placing the core in a vacuum bag pressed against a curved molding, and placing both in an oven. A steady increase in heat and vacuum pressure is then applied until the desired shape is attained. Moderate heat softens the core to a point where it will shape without cracking or breaking. The gradual vacuum bag forming maintains an even pressure throughout the honeycomb core. Guidelines to the actual process include the following: (1) the honeycomb to be formed is placed in a vacuum bag against the desired shape inside an oven; (2) the bag is then placed against the core for temperature recording purposes; (3) vacuum must not be applied until the oven has reached 350°F; (4) vacuum may then be applied slowly within the bag over a five-minute period until full vacuum is attained; (5) when the core has assumed the desired shape, the oven must be allowed to cool slowly to room temperature while retaining full vacuum. The vacuum pressure may then be eased off.


Desired Shape
High Density Phenolic H.C.B. Core

Source: Arnold F. Murillo of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-11405)

No further documentation is available.

ROLLER FORMING OF TUNGSTEN TUBING



This innovation eliminates several problems long encountered by industry in attempting to bend refractory metals (e.g. tungsten) at room temperature. One former process involved heating of refractory metals with gas heaters as they passed between rollers. The present method avoids this requirement.

The tungsten is first brought to a temperature of 500 to 600°F. Whereas formerly the length of tubing was limited by the width of the press brake, this restriction is now obsolete. Longer tubing can be formed from narrow sheet stock by passing it through a series of rolls, successively configured from perfectly flat to increasingly more concave and finally to a complete semicircle. A round bar passed through rolls on top of the strip stock, as shown in the figure, acts as a mandrel around which metal tubing is formed. Limits to the length of the tubing are governed only by the lengths of the mandrel and strip stock.

Source: Lewis Fabrication Shop Personnel
Lewis Research Center
(LEW-90201)

No further documentation is available.

FORMING COMPOUND CURVES FROM COMPOSITION CORK SHEETS

A technique which represents a radical departure from accepted procedures and has resulted in the highly successful forming (and bonding) of cork to compound surfaces is now available. The simplicity of the improved method should have considerable impact on industrial needs in terms of increased efficiency and reduced cost.

Where commercially available composition cork sheet stock must be applied to contoured surfaces for insulation purposes, the likelihood of cracking is always present. Equally unpredictable is the outcome of bonding cork sheet to contoured surfaces, especially where a sharp radius is required.

The procedure with the new method is that the material (a high density cork compound) is placed in an oven and heated to 350°F to soften the bonding agent. It is then removed and pressure formed by applying a vacuum bag to the mold or die during the cooling and curing stage.

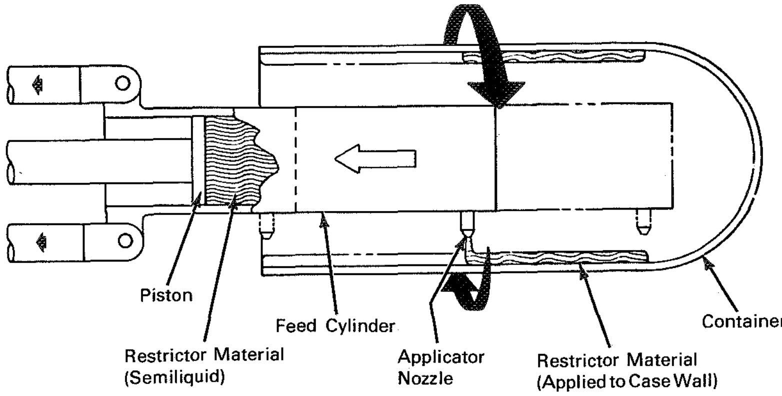
Source: W. R. Walker of
General Dynamics Corp.
under contract to
Lewis Research Center
(LEW-90394)

No further documentation is available.

APPLICATION OF SEMILIQUID INSULATING MATERIAL TO INTERIOR OF CYLINDRICAL SURFACES

A comparatively simple technique, which fills a frequent industrial need to apply insulating material to the interior of a cylindrical container or liquid storage vessel, is now in common use. In order to achieve the best results, it is essential that the semiliquid restrictor be applied with uniform thickness to the interior of the cylinder.

A prime requirement is a loaded cylinder with



the same unit length as the container to be lined. The cylinder, with a nozzle on the outboard end (see fig.) is positioned to correct depth in the container. With the piston held in a fixed position, the loaded cylinder is withdrawn from the container. This results in semiliquid restrictor material being deposited on the inner surface of the container in an amount equal to the volumetric displacement of the cylinder.

With the container revolving at approximately 12 to 17 rpm, while the loaded cylinder is slowly withdrawn, semiliquid insulator is precisely metered on the inside surface of the container, providing a permanent, uniform thickness. The only limiting requirement in securing a surface of even thickness is that the container must turn at least one rpm for each increment of semiliquid deposit from the metering nozzle.

Source: L. E. Balceszac of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-13731)

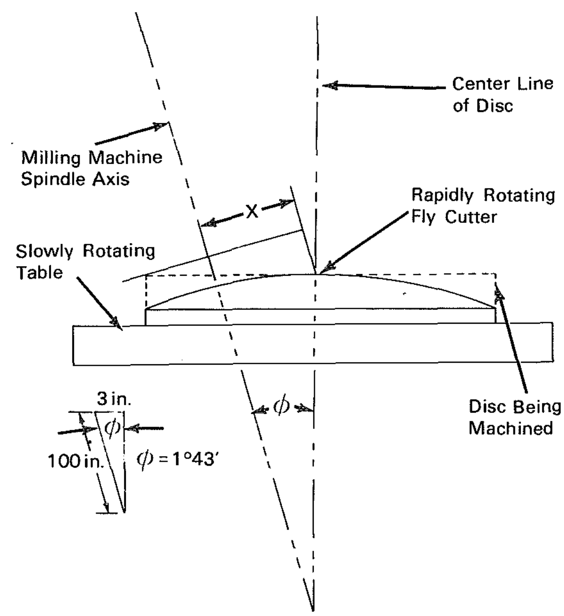
No further documentation is available.

GENERATING A LARGE CONVEX OR CONCAVE SPHERICAL SURFACE WITH A CIRCULAR MILLING MACHINE

The use of a milling machine makes it possible to fabricate a large radius spherical surface beyond the scope of a conventional lathe, as demonstrated by existing machine shop techniques.

The milling machine spindle axis shown in the figure is tilted at an angle of ϕ and the radius of the fly cutter is set to the required length. The disc is then slowly rotated under the rapidly spinning fly cutter.

Setting up the milling machine, the procedure is as follows: (1) a value is selected which exceeds half the radius of the disc for the fly cutter radius already determined; (2) this value is expressed to four decimal places and used to calculate the tilt angle ϕ. For a typical convex surface, assuming $x = 3.0000$ inches with a disc 10 inches in diameter, then for a 100-inch radius of curvature $\sin \phi = 3.0000/100 = 0.030000$. This is equivalent to a tilt of 1°43′; (3) the vertical axis of the milling



machine is set to the calculated angle with a sine bar; (4) the disc is centered on a slowly rotating table with the arc of the fly cutter passing over the exact center; (5) with the disc rotating slowly under the fast turning fly cutter, the required spherical surface is generated. A relatively smooth surface can be obtained by slowing the disc's rotational speed for the final cut. A concave surface can be generated by simply tilting the axis of the milling machine in the opposite direction, ($-\phi$).

Source: Anthony Walch, Jr.
Goddard Space Flight Center
(GSC-10575)

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CORK COMPOSITION SPACER FOR ROLL FORMING

An adhesive backed spacer has been developed that can be applied to a workpiece as protection for raised channeling during roll forming

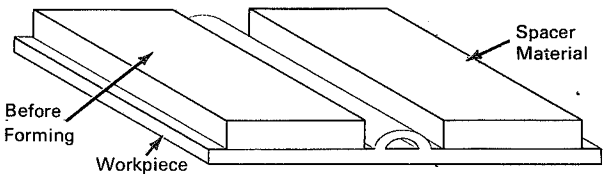

Figure 1

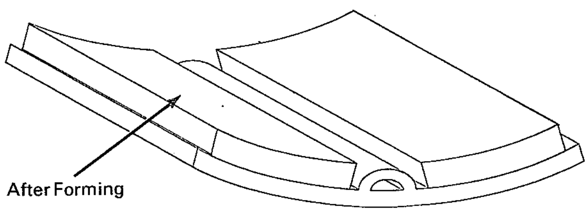

Figure 2

operations. Its industrial use in metallurgical fabrication should result in worthwhile savings and improved roll forming.

One of the problems during roll forming has long been the deformities appearing in raised sections and the resultant rejection of these parts.

The spacer material employed in this new technique is an adhesive backed composition cork and rubber sheet. Strips or shapes with a thickness of 1/16-inch or 1/8-inch are cut and laid on the surface to be roll formed. (The upper figure shows a workpiece with the material applied before forming.)

A 10 psi load can be applied during forming of light sheet metal without damaging the spacer material. This reduces the possibility of the roll deforming raised channels or sections. (The lower figure shows the same workpiece after roll forming.) The spacer is inexpensive and can easily be removed and reused several times. Spacer material also can be used when cutting dies to aid in the separation of mating sections.

Source: V. Eckstein and H. Z. Lewis of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-90755)

No further documentation is available.

FORMING, MACHINING, AND WELDING OF RHENIUM

A breakthrough in forming the refractory metal rhenium into extremely small hollow parts with rather sophisticated inside shapes has been achieved by vapor deposition. Rhenium can be deposited (at a temperature of 975°K) on a sacrificial material, such as titanium, which is later removed with a hydrofluoric acid solution. Rhenium is vapor deposited by passing H_2 and $ReCl_5$ (usually) gas over an induction-heated mandrel. The mandrel was machined from titanium (A-55) bar stock and then stress-relieved by annealing in a vacuum retort furnace (10^{-3}torr) at 815°K for one hour. This annealing prevents distortion of the small parts when residual stresses are released during subsequent processing.

Machining of rhenium is very difficult because of its large coefficient of work hardening, which rapidly turns over even carbide-tipped tools and drills. However, rough machining can be done by torch-heating during turning. This work hardening property of rhenium makes frequent annealing necessary. A recommended annealing temperature

Joint	Thickness	Voltage (kV)	Current (mA)	Spot Diameter	Travel (cm/min)
Tee	0.5 to 0.5 mm	130	2.5	0.15 mm	50
Tee	0.5 to 0.125	130	3.05	0.25 mm	50 - 70 percent joint pickup during a repair
		130	3.6	0.25 mm	50 - 100 percent penetration
Lap	0.25 to 0.125	90	2.2	0.15 mm	18.3 - made by circle generator

for 0.005 to 0.120 in. material is 1925°K for 5 to 30 minutes in an oxygen free atmosphere.

Rhenium may be drilled by eloxing (electro-discharge) and by using diamond-core tools. Outside diameters and contours may be readily ground with an aluminum oxide wheel.

One of the major advantages of rhenium is that it remains ductile after being heated above its recrystellization temperature. This property makes rhenium extremely tolerant to electro-beam welding (perhaps the best known technique for joining refractory metals) or to tungsten inert gas (TIG) welding and subsequent reworking.

Because little information was available on electron-beam welding of rhenium, some typical joints were made to establish weld schedules which are shown above.

Source: The Marquardt Corp.
subcontractor to Douglas Aircraft Co.
under contract to
Langley Research Center
(LAR-10457)

No further documentation is available.

ICE DIE FORMS SPHERICAL CONTAINER: A CONCEPT

A concept of recent origin in the forming of spherical containers merits both industrial study and testing. The new technique permits a spherical container to be fabricated by using a ball of ice as a form. The ice-ball form is the product of a freeze mold sized to the inside diameter of the metal container to be fabricated (Figure 1).

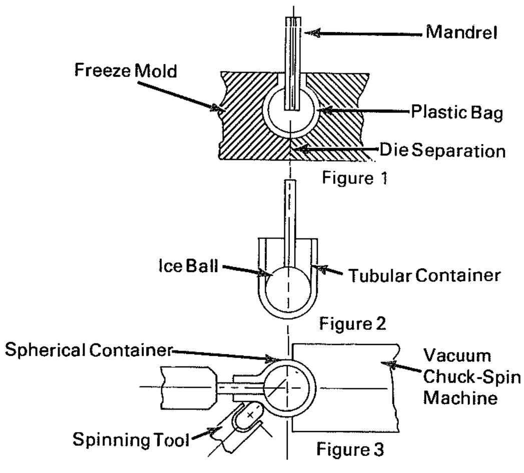

Figure 1

Figure 2

Figure 3

The recognized method of forming a spherical container has, in the past, involved the formation of two halves, then welding them together. This necessarily requires some very accurate machining and forming, with costs rising in proportion.

With the new method, water is poured into the mold through a hollow mandrel which projects into the spherical area. A thin plastic bag is attached to the mandrel to retain the water in the mold. The freeze-mold is then subjected to sub-zero temperatures to form an ice ball which retains its shape during the metal forming operation.

The first stage of metal work is accomplished by forming a tubular container, using a male and female die. The mandrel, frozen into the ice ball, is then placed in a tubular container (Figure 2) and, using the spinning tool and vacuum chuckspin machine (Figure 3), the spherical container is formed to the shape of the ice ball. After the spinning operation is completed, the ice is melted and the mandrel removed, leaving a completed spherically shaped container.

Source: E. C. Jackson of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-91098)

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MAGNETIC FLARING DEVICE

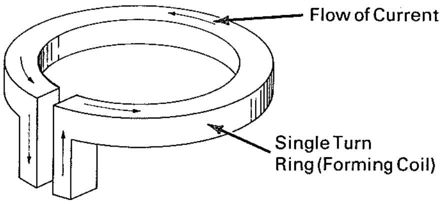

Figure 1

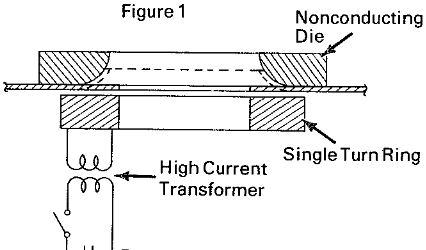

Figure 2

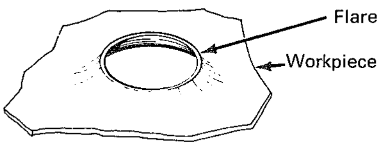

Figure 3

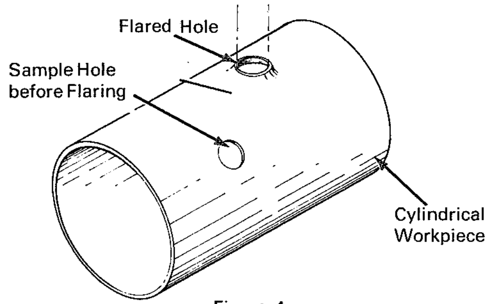

Figure 4

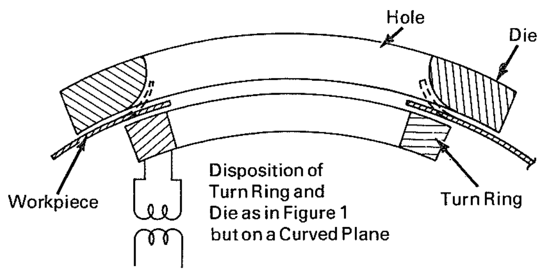

Figure 5

The use of a prototype electromagnet specifically as a flaring device for a metallic workpiece has several advantages over other forming processes which rely on manual skill. Since these demand time consuming work with hammer and die to meet the required standards of accuracy, they are necessarily more costly, slower and less uniform.

Because of instantaneous forming generated by substantial magnetic pressures, this technique has proved highly successful in flaring metal workpieces, either with a flat or a cylindrical surface. The basic principle is very simple. A massive single turn ring (or forming coil) of the same diameter as the hole already cut in the workpiece (see Figure 1) is placed directly underneath. A circular die with the required flare is then located directly above, as shown in sectioned view (Figure 2), and is connected to a high current transformer, also seen in Figure 2. The transformer derives power from a capacitor bank. When the switch closes the circuit, a high intensity magnetic field is generated around the perimeter of the hole. The immediate effect is that of evenly flaring the rim of the hole upward against the inner curve of the die.

The end product is shown on a sample workpiece (Figure 3). This type of flare provides a useful and accurate fitting at the hole on which to attach a tube. The same principle is applicable to a cylindrical workpiece (sectional Figure 4) using a similar die and turn ring shaped to conform to the curved surface of the workpiece (Figure 5).

Source: Ralph W. Waniek of
Advanced Kinetics, Inc.
under contract to
Marshall Space Flight Center
(MFS-13526)

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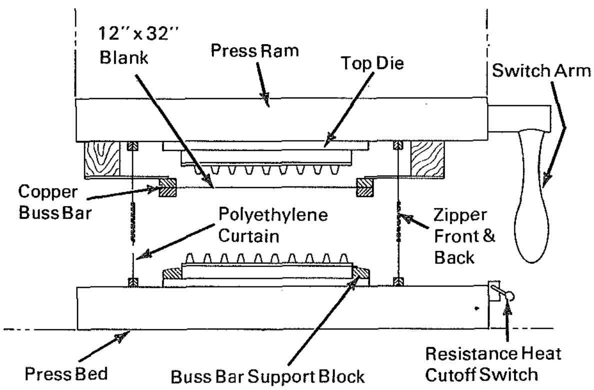
DIMPLED SHEET FORMING

A forming process has been developed that permits 0.004 and 0.006-inch metal sheets to be dimpled in various configurations for added strength. This process has produced very good results in dimpling sheets of tough metal such as titanium, Rene 41, and columbium alloy.

The titanium alloy forming process requires the following equipment: (1) a 50-KVA resistance heating unit to supply energy to the titanium blank; (2) a 4-inch stroke, 90-ton mechanical form press to dimple the plates; (3) a polyethylene curtain around the die to enclose the blank in an argon gas atmosphere during heating; (4) a set of adjustable form dies that can accommodate 12-inch by 32-inch blanks; and (5) a set of copper buss bars in the form of a rectangular frame to suspend the blank between the upper and lower dies, permitting a uniform flow of current through the blank. Depending upon the blank thickness, one of two sets



of dies can be used. Dies for the 0.004-inch blanks have a pitch pattern (distance between dimpling pins) of 0.600-inch. Dies for the 0.600-inch blanks have a pitch pattern of 0.65-inch. Both sets of dies permit dimple depths up to 0.234-inch.

Equipment for hot forming both titanium alloy and Rene 41 is shown in the figure. Titanium blanks must be thoroughly cleaned before the forming process begins. After cleaning, the blanks must be handled with white cotton gloves to avoid finger print contamination. For all forming operations, the titanium blanks must be clamped in a copper frame, the polyethylene bag closed and purged with argon gas to prevent contamination, and the heating unit set to attain 1800° F. The press ram should be adjusted to provide approximately three-fourths of the required dimple depth during the first forming operation. This operation is repeated three more times with the press ram adjusted each time to form the sheet 0.020-inch deeper, until full dimple depth is achieved.

When forming Rene 41, polyvinyl chloride cover plates are applied to the die during the first two forming operations to prevent cracking of the metal. Before the third and final operation, the Rene 41 alloy is annealed in a vacuum furnace at 1975° F for 30 minutes.

Columbium alloy is cold-formed in a 450-ton hydraulic press by a similar process without the use of heating unit, vacuum furnace, or argon atmosphere. As in the forming of Rene 41, however, polyethylene chloride cover plates are used in the first two of the three forming operations to prevent cracking of the metal sheet.

Source: J. E. Broderick of
Martin-Marietta Corp.
under contract to
Langley Research Center
(LAR-90067)

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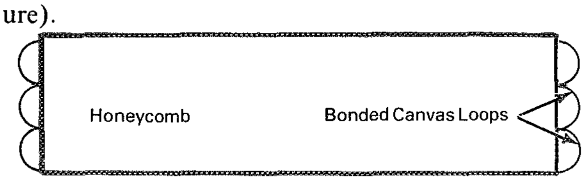
CANVAS LOOPS FOR STRETCHING CORE

In a new and different approach to the problem of stretching a honeycomb plane or core, an aluminum or stainless steel unit is stretched by using canvas loops bonded at both ends (see figure).



The earlier procedure was to push pieces of drill rod through the core, prior to stretching. This method, however, does not always produce an even pull, and the core cells can often be distorted.

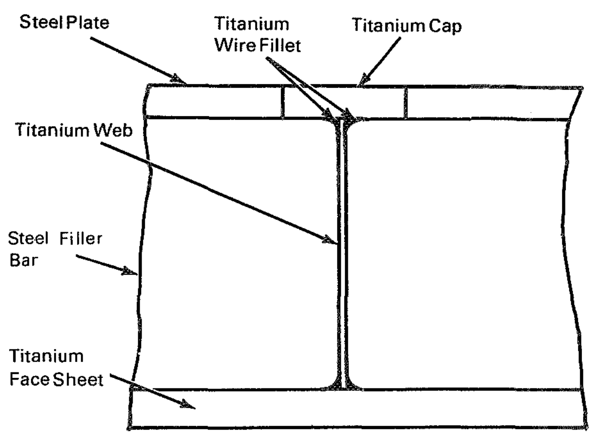
The subject innovation calls for rods to be placed inside the loops to stretch the core. The canvas loops can be bonded to the plane or core before it is cut to the desired thickness. In this way there is little or no waste while cells retain uniform shape throughout the blanket.

Source: Fred H. Curtiss of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-11420)

No further documentation is available.

CORNER FILLETS FOR DIFFUSION BONDED ASSEMBLIES

The problem of forming titanium roll bonded panels has now been overcome by a method that produces corner fillets in diffusion bonded structures, using titanium wire in the space between a steel filler bar and a titanium joint.



In the past, titanium roll bonded panels have been subject to cracks because of relatively sharp corners in the bond joint area.

In the new process, the corners of the steel filler bars contacting the titanium joint are machined to 1/8 inch radius to provide a space for the titanium wire fillet during layup (see figure). The assembly is then reduced 60% in a roll diffusion bonding process. When the steel filler bars and plates are removed, the remaining titanium structure has a better bond joint with improved structural integrity, longer fatigue life and greater crack resistance than were previously obtained.

Source: J. B. Bennett and A. G. Jones of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-92017)

No further documentation is available.

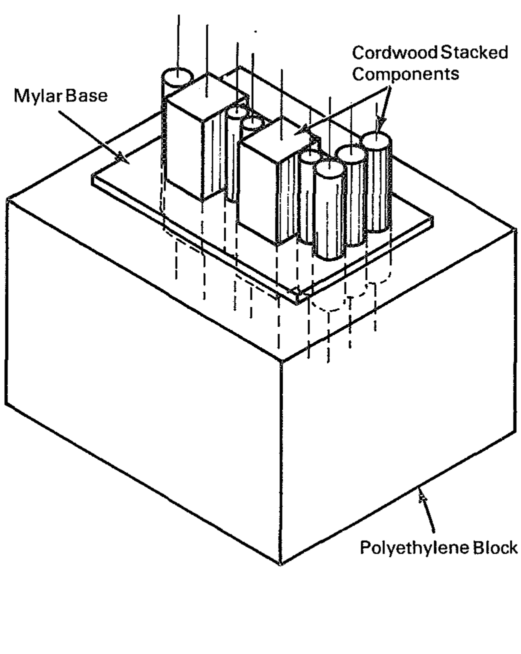
Section 4. Miscellaneous Fabrication

FOAM BLOCK HOLDING DEVICE FOR ELECTRONIC SUBASSEMBLIES

Improved technology involving the use of a polyethylene foam block as a holding device for "cordwood" stacked electronic modules, and terminal boards and similar layout fixtures, has resulted in timesaving, more efficient assembly. The new foam block also provides a backup into which the leads can be inserted, protecting them while holding the components in place. This holding device should prove valuable to industry in any activity where welded modules or assemblies are produced, using the cordwood technique.

Difficulties encountered in the past have included integrity leads being damaged, with a resultant loss of time until the leads were welded.

The essential part of this innovation (see fig.) is the polyethylene foam block which is slightly larger than the length and width of the module to be assembled and slightly deeper than the length of the leads. A mylar base with holes punched in



it, which follow component patterns, is laid over the polyethylene. Components are assembled by inserting them into the polyethylene through the mylar pattern. This serves to protect the leads while holding the components in place. The exposed leads are allowed to extend vertically, permitting easy insertion of the miniature printed circuit.

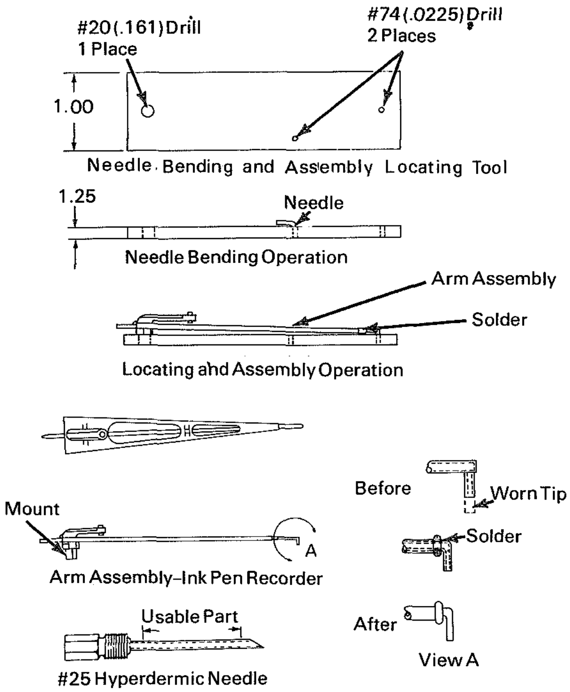
The final step is the cutting and welding of the leads as required. This new method of assembling components in cordwood fashion through a mylar layout pattern protects the leads and body of the components from damage.

Source: G. E. Grant, Jr. of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-91928)

Circle 9 on Reader's Service Card.

LOW COST RENEWAL OF RECORDER PEN TIPS

A valuable technique has been evolved for salvaging the recorder arm assembly in multichannel ink pen recorders used in data reduction laboratories. The ink pen arm assembly can now be retained at a saving of \$25.00 by using a 25¢ hypodermic needle.



Tip Replacement-Ink Pen Recorder

The main drawback with the existing system has been the short life of the pen tips. Since each recorder is equipped with eight data and two event markers, this has resulted in considerable cost for the required periodic replacements, which are fairly frequent. In such cases, the usefulness of the entire arm assembly also is compromised.

The new method consists in replacing the worn pen tip with a No. 25 hypodermic needle. The needle fits snugly within the stainless steel ink supply tube. By retaining the needle in a No. 74 hole of the bending block (see figure), it can be bent 90 degrees without closing the passage.

When the new tip has been trimmed to desired length, it can then be positioned in the assembly tool and soldered in place with a 60/40 soldering wire.

Source: J. L. Hanson of
General Dynamics Corp.
under contract to
Lewis Research Center
(LEW-10400)

No further documentation is available.

MYLAR FACINGS FOR SOFT TOOLING (JIG BOARDS)

The use of mylar facings in producing jig boards designed for use by electrical manufacturers of wire harness assemblies has resulted in considerable savings. The cost of jig boards is reduced and mylar can be secured with tape; blueline facings currently used have to be cemented. Subsequent changes to mylar facings can be made by eradicating, but changes to blueline facings require a further cementing of blueline patches.

Jig boards designed for electrical manufacturers are usually made of ¾-inch plywood, and the layout on blue line paper facings outlines and controls harness configuration and dimensions.

The new technique features six distinct advantages: (1) blueline facings fade whereas mylar does not; (2) cementing process is eliminated; (3) need for working out of the area because of noxious fumes from the cementing material no longer exists; (4) labor and material costs are reduced; (5) hazards raised by flammable material are removed; and (6) mylar facing does not stretch, whereas blueline paper is subject to distortion.

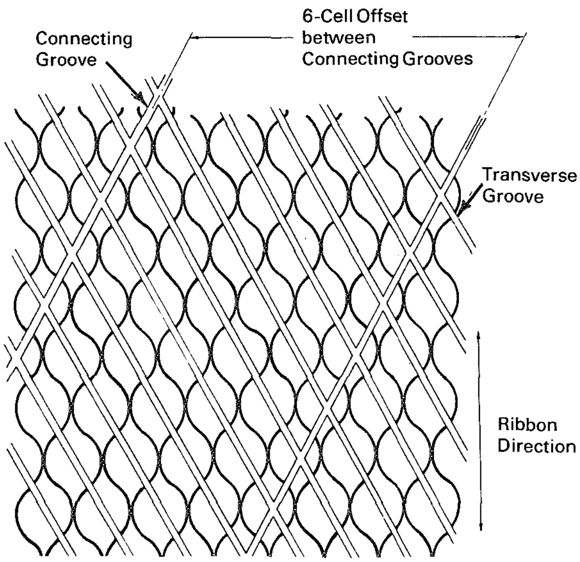
Source: D. Y. Ariaz of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-11159)

No further documentation is available.

VENTING METHOD FOR HONEYCOMB CORE

A new technique eliminates the problems of ventilating honeycomb sandwich construction which are fairly common to industry, especially where lightweight monocoque buildings are involved, as in campsites.

Ventilation of honeycomb structures, however (sometimes needed for bonding purposes, or where differences in altitude or temperature may require compensation), presents various problems.



The improvement provides adequate liquid flow passages through honeycomb walls, as shown in the figure. Formerly, the procedure was to drill holes through the cell walls to interconnect a cell with an adjacent one. The new method uses grooving of the core, thus providing greater flexibility of design. Grooves can be applied where required, while ungrooved areas serve as a seal in between to provide flow channels for ventilation.

The wall is grooved, using a circular saw or other grooving tool on the top or bottom of the honeycomb. This method provides both flow and purging capability as needed. Grooves are cut to a nominal width of 1/16th inch and a height of 3/16th inch. Each cell is interconnected in one direction. In the opposite direction, the groove is cut every sixth cell.

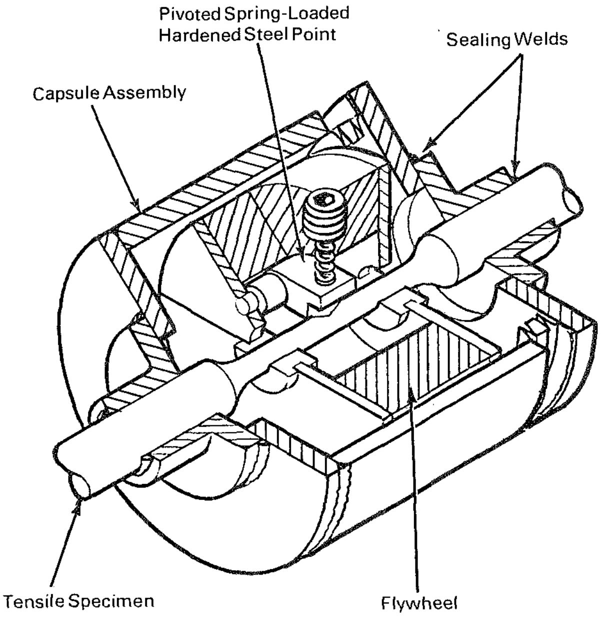
Source: S. L. Frederickson of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-91788)

Circle 10 on Reader's Service Card.

GALLING ENCAPSULATED TEST SPECIMENS

The most highly successful method used by commercial testing laboratories primarily concerned with metallurgy, involves the use of an atmosphere container for environmental testing of materials under controlled conditions. Since no moving seals are used, the test metal can undergo stress without risk of exposure to air. For instance, the reaction of metal under stress (tensile or compression) when exposed to hydrogen can provide valuable data to steel corporations and manufacturers of metal.

The problem, however, has been to carry out these tests under efficiently controlled conditions (where oxidation would not attack the exposed metal) to permit a true surface test. The solution has not always been simple or foolproof because of the problem of encapsulating the test specimen while exposing it solely to a specific environment.



With the present method, a segmented flywheel is constructed to fit within the atmosphere container, around the specimen gage length. Included also is a rubbing block with a pivoted, spring-loaded hardened steel point capable of galling or abrading the test metal, as shown in figure.

The operating principle is as follows: both specimen and flywheel (designed to fit within the atmosphere container) are loaded into it and sealed off by welding. This permits the evacuation of the container and its filling with the desired gas. The grip ends of the specimen are then chucked in a lathe which is accelerated to 1500 or 2000 rpm, and stopped abruptly. The flywheel continues to rotate on its own momentum, but there is now relative motion between rubbing block and specimen. The motion causes the rubbing block to scribe a shallow groove around the specimen without risk of oxidation. In this manner, the atmosphere within the sealed container (hydrogen for example) is able to react on a pure metal surface.

Source: J. N. Lamb of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-14077)

No further documentation is available.

PRESTRESSED, WHISKER-STRENGTHENED ZIRCONIA

A report on a technique which may have a revolutionary impact on the commercial manufacture of artificial bones, concerns the use of whisker-strengthened zirconia—a prestressed ceramic combined with silicon carbide (SiC). This new material should also prove useful for hot gas ducting and as a form of armor for personnel, aircraft and helicopters.

Normally, ceramics such as zirconia are brittle and possess low tensile strength. By prestressing them with tungsten cables their tensile load carrying ability is increased. At the same time the material acquires an artificial ductility alien to normal ceramics. The addition of silicon carbide whiskers improves the ductility and increases the strength of the ceramic at elevated temperatures in the region of 2000° F.

Component analysis shows the ceramic matrix to be made up of 60 parts by weight of coarse calcia stabilized zirconium oxide (-70 +200 mesh); 40 parts by weight of fine calcia stabilized zirconium oxide (-325 mesh); eight parts by weight of SiC whiskers and 32 parts by weight of monofluorophosphoric acid. These ingredients are mixed and placed in a mold containing pretensioned tungsten cables (or onto a rigid mandrel overwound with pretensioned tungsten cables). The assembly is then cured at a maximum temperature of 600° F. On completion of the cure cycles, the end restraints of the cable are removed, placing the ceramic in compression.

In the case of a ceramic cylinder, this is removed from a rigid mandrel which allows it to shrink, thus inducing precompression of the ceramic. The advantages of this method are: (1) low temperature (600° F) processing of the ceramic which prevents loss of strength of prestressing media due to thermal exposure; (2) added strength at 70° and 2000° F due to the addition of the SiC whiskers; (3) immunity to thermal shock failure (demonstrated by inserting a specimen for 20 minutes into a furnace preheated to 2000° F); and (4) the ability of the prestressing material to stop crack propagation, even where a cylinder was subjected to a high velocity ballistic impact with armor piercing 30 06 projectiles. Failure was localized and noncatastrophic, while the prestressing material completely stopped any crack propagation.

Source: Longin B. Greszczuk of
McDonnell Douglas Corp.
under contract to
Marshall Space Flight Center
(MFS-20322)

No further documentation is available.

RIGIDIZING HONEYCOMB WITH PARADICHLOROBENZENE FOR MACHINING

A new technique, using a different approach, has reduced the risk of honeycomb damage to an acceptable level during the bonding and brazing of steel honeycomb sandwiches for machining and forming.

Previous conventional cutting often damaged the core of the honeycomb, while forming methods crushed it.

An undersize hole is now cut in the face sheet of the honeycomb, using a drill, bow saw or end mill. The exposed core is filled with molten paradichlorobenzene (commonly found in mothballs). A hole of the desired size is then cut with a drill, reamer, bow saw, end mill or file, refilling the exposed portions of the honeycomb core as necessary. When the hole is completed, the bulk of the remaining filler is removed by blowing with hot air, not over 250° F to melt the filler, and by hot vacuuming. The residue will evaporate through sublimation at room temperature. The filler is used in the same way to impart rigidity to the core for roll-forming or brake-forming.

Source: K. Loo of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-90912)

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NASA-Langley, 1971

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